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ON

HORN, TORTOISESHELL, AND BONE.

By THE SECRETARY.

With regard to the mechanical uses of bone, it may be observed, that the spinous bones in the back-fins and tail of certain fishes, especially the serrated tail-spine of the sting-ray, and of some others of the same species, from their size, sharpness, hardness, and toughness, have been used for pointing arrows or spears by some of the ancient nations, as they are at present by many savage tribes, forming weapons of the most formidable description, from the jagged, lacerated wounds which they produce. The serrated teeth of sharks, inserted on the edge of a staff of heavy wood, afford another instance of animal bone, unchanged in figure by the use of any tool, being employed as the essential part of offensive arms.

The interior bones of animals are also used for the same purpose; but to adapt them to this use, they require to be fashioned by rasps and other tools into simple or jagged points. Fish-hooks are also very ingeniously made of the same materials by the inhabitants of some of the South Sea Islands, as well as by the Esquimaux. The latter people, indeed, from their almost total want of wood, are obliged to find substitutes for it in the bones of whales and the tusks of the walrus, which, accordingly, are the material of many of their domestic and other implements. Bone, when thin, has a considerable degree of elasticity ; and this property is ingeniously taken advantage of by the Esquimaux in their fish-spears.

The bones of fine texture, especially the teeth or tusks of the hippopotamus, the elephant, the walrus, and the narwahl, are an excellent material on which to exercise the arts of carving or sculpture, and of turning in the lathe; and which has been taken advantage of by many nations in very different states of civilisation. Phidias is said to have used ivory, among other materials, in fabricating the colossal statue of Minerva at Athens; but ivory was not a material on which the sculptors of ancient Greece were fond of exercising their skill.

The Romans seem to have used ivory, rather as a material for inlaying and otherwise ornamenting furniture than for sculpture. The artists of India and China have immemorially been celebrated for their exquisite and intricate sculptures of ivory and bone; and specimens of beautiful chain-work in the same material illustrate the skill of the artists of Archangel. Other northern tribes of the Russian empire amuse themselves, probably during the long leisure of their winters, by representing in rude sculpture the bear, the fox, and other wild animals of the polar regions. In this country ivory and bone are not sculptured, but are turned in the lathe or fashioned by means of other tools into various articles of ornament and use. Thus, tooth and nail-brushes, handles of knives, combs, paper-knives, and a variety of smaller articles, are made of ivory or bone, the latter of which has the advantage of being harder, whiter, and little liable to become yellow with age, and, when employed on small objects, may be had of a grain nearly as fine as ivory.

The scrapings, shavings, or sawdust of bone is an article that bears a good price in the market, being much used by pastrycooks and others as a material for jelly, which it readily gives out to boiling water. The jelly thus produced is probably quite as good as that from calf's foot; and the shavings, when dry, have the advantage over calf's foot of not suffering any change by keeping. Another use, of considerable importance, to which bone-shavings are applied, is in case-hardening small articles of steel.

Bones have always been used as one of the ingredients of that multifarious mixture of offal of all kinds — a dunghill; but it is only of late years that their extraordinary value as a manure has been fully ascertained. About forty years ago, an acquaintance of mine was cultivating a small estate of his own, and, from not having been originally brought up to farming, was the more ready to try novel experiments. A pack of hounds was kept in his neighbourhood; and this furnished him with an opportunity of obtaining at small cost the bones of the old horses and other animals that were slaughtered for food to the dogs. He invented, or got made for him, a machine for crushing the bones; and then spread them, as a top-dressing, on a grass field, the soil of which was a sour, red clay, that produced nothing but dyers'-broom, and the other weeds that usually grow on such soil along with the coarsest grasses. The effect produced by the bones was strikingly evident in the next spring: the dyers'-broom and other weeds had mostly disappeared, and a close undergrowth of clover and fine grasses was making its appearance. The animal matter of the bones no doubt contributed much to this striking amelioration; but the earth of the bones, especially the phosphate of lime, also bore its share in it, as this earthy salt is found in the ashes of clover, and probably of other plants. Many of our limestones are little else than a congeries of the organic remains of corals and other animals; and the late Professor Turner detected the presence of phosphate of lime in the Saurian remains that abound in the lias limestone. Many of the corallines, as I have already stated, contain as much phosphate of lime as the bones of mammalia do; it is probable, therefore, that in the coralline limestones also phosphate of lime might be found if it was specially searched for; and to the presence of this, if authenticated, may, perhaps, be attributed some of the effects on vegetation which agricultural chemists are in the habit of accounting for by the action of caustic lime, or of its carbonate.

I do not know if bones are valued as a manure in any part of the continent of Europe; but it is certain that of late years they have attracted, in a very particular degree, the attention of the English farmer. Bones are collected in the streets of London, and other great towns, and after being sorted, those that are not required for other purposes are used as manure. In the Thames, above London Bridge, may almost always be seen a few sloops and cutters, chiefly from Hull, which are occupied in this trade. They take the bones on board generally in a more or less putrid state, and stow them in bulk in the hold: here they soon begin to ferment, giving out an odour by which the bone-ships are detected at a considerable distance; and when the cargo is discharged at Hull, it is frequently reeking and smoking hot from decomposition. This probably softens the texture of the bones, and renders them more easy to be crushed in the mill through which they are passed previous to disposing of them to the farmers. They are employed chiefly in two ways, either as a top-dressing to grass land, or are drilled with turnip-seed, the plants from which, under the stimulating effect of this powerful manure, quickly pass through their first stage into the rough leaf, and thus, in a great measure, avoid the attacks of the *fly* and other insects by which young turnip-plants of tardy growth are often entirely cut off. Our native supply of bones is not at present sufficient to answer the large and increasing demand for them for agricultural use; and bones are now imported from South America and other parts. It is even said that some of the celebrated battle-fields of our own time have furnished considerable supplies of this now valuable commodity.

I now proceed to describe the action of heat on bones; first, in the open air, and secondly, in close vessels.

If we throw into the fire a bone, even of the most solid kind, and from which all oily matter has been carefully separated (an old toothbrush will serve for an example), it will be found first to crack, and then to burn with a large and bright flame, in consequence of the combustible gases into which the animal matter of the bone is in part resolved. If the bone is taken out of the fire as soon as it ceases to flame, it will be found to be of a bluish-black colour, from the charcoal which is the residue of the decomposition of the animal membrane. If the blackened bone be returned to the fire, the whole of the charcoal is at length consumed, and nothing remains but the white earth of the bone, commonly called bone-ash.

If instead of a single one a heap of bones is employed, and a fire is kindled in one part, it will spread by degrees to the whole heap, giving out more or less flame and a strong heat; and in the treeless steppes of Tartary, and the pampas of South America, the inhabitants make up for the want of other fuel by burning the bones of their cattle, it being considered that the bones of an ox will produce heat enough to cook its flesh by. This, therefore, is another to be added to the many uses of bone. But by burning bone in an open fire, no other product is obtained from it except the ashes, while the horribly noisome odour of the gas which escapes combustion, renders this process a sore nuisance in any inhabited neighbourhood.

The decomposition of bone by heat in close vessels, whereby the action of atmospheric air is excluded, is well worthy of minute attention, both in consequence of the large scale on which it is carried on as a process of chemical manufacture, of the importance of the products obtained, and of the interest which it possesses in a scientific point of view. I shall, therefore, conclude this evening's illustration by examining this part of my subject with some minuteness, avoiding, as far as I can, mere chemical details, as being little suited to a miscellaneous audience.

The animal matter of bone is the only constituent part of this substance susceptible of decomposition by a heat brought up to low redness: in considering, therefore, the action of close heat on bone, the earthy ingredients may be considered as passive. The animal matter is either a substance analogous to skin, or is a mixture of membrane and jelly: the former opinion is supported by some of the most eminent modern chemists, but it is of no sort of importance to our present purpose which opinion is adopted, as all three substances are composed of the same ultimate elements and nearly in the same proportions. The four simple substances, then, of which the animal matter of bone is composed, are carbon, hydrogen, nitrogen, and oxygen; and of these the three latter, when in an uncombined state and at the usual temperature and atmospheric pressure, are in the form of gas. Now, when it happens that three substances, habitually gaseous, are combined with one naturally solid, and when these four substances are likewise capable of uniting together by twos and threes, or, in other words, of forming binary and ternary compounds, the attraction that holds together all the four is easily disturbed by a moderate increase of temperature; in consequence of which the same elements, by arranging themselves differently, produce two or more different substances.

This is the case in the present instance. On exposing bone shavings even to a lamp heat, they are observed immediately to become black; shewing that the new compounds that are the result of this decomposition are not capable of combining with the whole of the carbon, but that part remains in the state of charcoal intimately mixed with the earthy matter. This mixture goes by the name of bone-black, or animal charcoal, the uses of which I shall detail by and by.

Part of the carbon combines with part of the oxygen, and forms carbonic acid, while part of the hydrogen and part of the nitrogen produce ammonia; the carbonic acid and the ammonia, as they are formed, combine and produce carbonate of ammonia, which, therefore, is another of the useful substances resulting from the decomposition of bone. Part of the oxygen and hydrogen combine and produce water; and part of the oxygen, the hydrogen, and carbon, by combining, produce a volatile oil of a strong and peculiar odour, which goes by the name of animal oil. The remainder of the carbon and hydrogen, with probably some nitrogen, combine and produce an inflammable gas. Thus the decomposition in close vessels of the single substance, bone, produces five new substances; namely, animal charcoal, carbonate of ammonia, animal oil, water, and an inflammable gas. A low red heat volatilises all these substances, except the first; which, therefore, when the process is performed on a large scale in iron vessels, remains in the retort separated from the other four compounds. The water, the carbonate of ammonia, and part of the oil, are condensed, and remain in the receiver; the inflammable gas, holding in solution another part of the oil from which it derives an inconceivably nauseous odour, passes off through a pipe, and is either conveyed into the ash-pit of the furnace, whence it is drawn up among the burning fuel and is consumed, or is set fire to as it issues from the mouth of the pipe; by either of which methods its noisome smell is for the most part avoided. The ammoniacal liquor likewise combines with a little of the oil, from which, however, it may for the most part be separated by redistillation; enough, however, of the oil remains united with it to produce that particular modification of odour by which spirit of hartshorn (for so this substance is commonly called) is distinguished from pure ammonia; or, by other processes, unnecessary here to mention, the ammonia is obtained entirely free from the oil.

I now return to the animal charcoal, which I have already briefly mentioned. When obtained from bone, it is called bone-black; when from ivory, ivory-black; the difference between these two being merely that of texture and some slight tint of colour, for they both are an intimate mixture of carbonate and phosphate of lime with charcoal, resulting from the decomposition of animal matter. Till of late, the only use to which this substance was put was as the basis of black pigments, ivory-black having been first so applied by the celebrated Greek painter, Apelles.

Some years ago, a German chemist, of the name of Lowitz, settled at Petersburg, discovered that common charcoal, when fresh burnt and in fine powder, has the property of taking away the colour of common vinegar and of several other liquids, and likewise of removing the odour proceeding from vegetable and animal substances in a state of spontaneous decomposition. This interesting and valuable fact was soon applied to the clarification of various liquors in pharmacy, and as an auxiliary in the art of refining sugar. About the year 1811, M. Figuier, of Montpellier, ascertained that charcoal from animal substances not only is equally efficacious when used in considerably smaller proportion than vegetable charcoal, but that it is capable of decolouring many liquors, on which the latter has no sensible effect whatever. This discovery created immediately a demand for bone-black in this country, and in all the other manufacturing countries of Europe, those especially in which refined sugar is obtained either from brown cane-sugar or from the juice of the beet. A considerable difference in efficacy was soon perceived between different parcels of bone charcoal; and chemists of no mean name set themselves to work in order to discover the theory of the decolouring action of charcoal, and some method, if possible, of increasing the efficacy of the inferior varieties of it. It is certain that the more finely divided any given weight of the charcoal is, the more powerful is its decolouring effect; and thus the inferiority of those kinds of charcoal that break with a glossy fracture, when compared with those of a dull fracture, is accounted for: the particles of the former being assumed to be nearly solid, and those of the latter to be porous, or, in other words, more minutely divided. In bone charcoal the carbonaceous particles are separated from each other by the large quantity of earth with which they are mixed, and hence the superiority of this to vegetable charcoal seems to resolve itself into a case of very minute division. Still, however, the question remains to be answered, What kind of action, chemical or otherwise, is it that exists between charcoal and certain colouring and odorant substances; and what is the nature of the compounds or mixtures resulting from this action? It has been ascertained as a fact, though the reason is yet to seek, that wood charcoal ground to fine powder, and then mixed with carbonate of potash and exposed to a red heat, becomes, after the alkali has been washed out from it, nearly as efficacious as bone charcoal; and that this latter, by a similar treatment, has its clarifying power greatly increased.

For many uses the presence of the earthy part of bone charcoal is no hinderance, but in those cases in which it would be inconvenient or injurious, it is necessary to steep the charcoal, previously pulverised, in dilute muriatic acid for a day or two, by which the whole of the earth will be dissolved, and may be separated by filtration and subsequent washing from the merely carbonaceous part, which will be found to have sustained no deterioration of its clarifying power by this treatment.

A few words yet remain to be said concerning the earthy basis of bones. This, as I have already stated, is a mixture of carbonate and phosphate of lime, the latter salt being in by much the largest proportion.

Many are the uses to which bone-ash is applied. When ground to moderately fine powder, it is the material of which the cupels of the gold and silver assayers are made, being at the same time very infusible and sufficiently porous to absorb the litharge and other impurities, while the fine metal remains on its surface.

When levigated and washed over, it forms an exceedingly useful polishing powder for plate and other articles. It is likewise the only material from which phosphorus is at present prepared. Part of the phosphoric acid is separated by the action of sulphuric acid from the lime with which it is combined in the bone-ash; and this portion, when mixed with charcoal powder and strongly heated in an earthen retort, is decomposed; the phosphorus is liberated in the form of vapour, and is consolidated by coming in contact with the cold water in which the beak of the retort dips. It is afterwards purified by filtration through leather in hot water, and is finally melted, likewise under water, in conical moulds, by which it assumes the usual appearance of stick phosphorus.

Many are the things thrown away as useless which, when circumstances allow of their being collected in considerable quantities, are found to be applicable to a variety of useful purposes; and in none is this observation more remarkably exemplified than in the subject of the present illustration. I have shewn that bone contains a considerable quantity of valuable nutriment, which may be extracted with greater or less ease in proportion as its cohesion is more or less overcome — that in its entire state it forms excellent handles for small brushes, and is also applicable to a variety of other similar uses — that the worker in steel employs it for case-hardening small and delicate articles — that, in proportion to its weight, it is the most valuable and active of all manures, and contributes in no inconsiderable degree to improve and increase the agricultural produce of all the districts where it is employed — that, in the absence of other combustibles, it may be and is largely used as fuel in the plains of Tartary and South America — that, by its decomposition in close vessels, it produces hartshorn, ammonia, and animal charcoal — and that, when burnt to ashes, it becomes useful to the assayer, furnishes a valuable polishing powder, and is the material from which phosphorus, that curious and interesting substance, the most combustible of all solids, is produced.